NOVA/BEAMLET/NIF UPDATES APRIL–JUNE 1998

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Nova Operations

Nova Operations performed 229 experiments during this quarter. These experiments supported efforts in ICF, Defense Sciences, university collaborations, Laser Science, and Nova facility maintenance. At the beginning of June, the operation of Nova expanded back to a full two shifts per day, with 2.5 hours of overlap between shifts. Nova now operates four days per week continuously from 6:30 a.m. to 12:30 a.m. This will allow the operations group to achieve the goal of 900 experiments in FY 1998.

Several new systems and diagnostics were added to Nova. The temporary installation of the $f/8.5$ lens system on one beamline was successful. Experiments were successfully performed utilizing this system both with and without an array of wedged KDP crystals for studying the effect of a polarization smoothing technique on the backscatter levels of various targets. New diagnostics, such as a driven wave Thomson scattering measurement system, were fielded. Another new system was added in the laser bay, which allows beamline 10 to be used as a backlighter. This increases the number of beamlines that can propagate the separate backlighter pulse to four.

Many improvements were made to the Petawatt system. Beginning in April, the first full-power target experiments were performed with the Petawatt deformable mirror. Using the sensor packages, it was determined that there are ~4 waves of static distortion in the Nova chain and several waves of thermal distortion due to heating of the amplifier disks. The mirror successfully corrects for these distortions by running a probe beam through the chain to the Hartmann sensor, and actively correcting the wavefront up to ~20 minutes before a shot. Averaging software was developed to keep the mirror from overcorrecting for turbulence occurring on a fast time scale. Pump-induced distortions are on the order of 1.8 waves peak-to-valley, and are corrected for by creating a precorrect file from the previous shot, which is applied immediately before the system shot. Because the cumulative wavefront correction is applied early in the amplifier chain, it was necessary to increase the diameter of the spatial filter pinholes early in the amplifier chain to avoid clipping. This allows high spatial frequencies to propagate through the chain, generating small-scale modulation in the near-field irradiance. This modulation causes a significant fraction of the beam energy to scatter outside the central focal spot.

Prior to using the wavefront control system, the focal spot at target chamber center was many times diffraction limited, with multiple hot spots within the central peak due to thermal distortion of the amplifier disks. With the deformable mirror, a single hot spot ~10 μm in diameter (full-width-half-maximum) is reproducibly delivered on target. This spot typically contains ~28% of the total energy in the central peak, corresponding to a maximum intensity of $\sim 4 \times 10^{20}$ W/cm^2 to date.

Beamlet Operations

During the third quarter of FY 1998, Beamlet continued to provide a testbed for validating the laser physics and engineering foundations of the National Ignition Facility (NIF). We completed a total of 128 full-system shots, 72 of which were dedicated to testing prototype NIF frequency converters, 25 to testing prototype fused-silica final optics at high 3ω fluence, and 16 to completing high-power, high-B-integral 1ω beam propagation experiments with angularly dispersed bandwidth as required for 1D smoothing by spectral dispersion (SSD). At the end of the quarter, we began a series of experiments for the French Commisseriat d'Energie Atomique (CEA) and completed a 15-shot campaign to measure thresholds for 3ω filamentation and damage in high-quality fused silica.

The frequency conversion work on Beamlet involved extensive testing of NIF production crystals, both conventional growth and rapid growth, in a 37-cm-aperture final optics cell (FOC) in the NIF-like vacuum environment of the Beamlet final-optics-assembly test mule. The purpose of the work was to validate the design of the NIF frequency converter and verify the physics models on which a detailed error analysis of its performance is based. As part of these tests, we measured (1) the second-harmonic conversion efficiency of a converter incorporating the first rapidly grown 37-cm type-I KDP doubler, (2) the third-harmonic conversion efficiency of a converter consisting of conventionally grown crystals from NIF production boules, and (3) the third-harmonic conversion efficiency of a converter consisting of the rapid-growth doubler and the first rapid-growth 37-cm tripler. Maximum efficiencies (whole beam, time integrated) were 70.5%, 75%, and 73% respectively measured at drive irradiances of between 3.6 and 3.9 GW/cm^2 in 1.5-ns square pulses. In each case, the measured efficiencies were within a few percent of modeling, assuming values for component transmissions measured prior to the experiments.

A small number of additional frequency conversion experiments were done to evaluate the effects of increased bandwidth with angular dispersion on 3ω efficiency, under conditions relevant to beam smoothing. Tests with 80 GHz (3Å) of 1ω bandwidth critically dispersed and 135 GHz (5Å) of bandwidth critically dispersed and 3× the critical dispersion condition showed reductions in efficiency to be less severe by ~30 to 40% than what was expected based on 2D modeling. The importance of choosing the correct dispersion direction was also demonstrated by reversing the sign of the dispersion along the tripler optic axis and measuring a corresponding reduction in efficiency of as much as 5%.

Tests to measure the effects of increased bandwidth and dispersion on 1ω beam quality in the laser amplifier were more extensive. The purpose of the measurements was to determine how the conditions for SSD reduce the operating margin against B-integral induced-beam breakup. The tests were conducted with 500-ps pulses using 167-μrad pinholes in the cavity spatial filter and with no pinhole in the transport spatial filter. The pulses were propagated through unpumped booster amplifiers to produce the high B-integrals expected at the end of a long, saturating ignition pulse. At B integrals in the booster amplifiers up to ~25% higher than the NIF limit of 1.8 rad, no difference in near-field beam quality was observed for the baseline SSD condition of 80 GHz critically dispersed, for which the divergence is ±7.5 μrad. Onset of beam degradation was observed when the divergence reached ±25 μrad, at which point the near-field irradiance contrast measured at a B of 2.1 rad was equivalent to the contrast measured at 2.3 rad without SSD, suggesting a reduction in operating margin of ~10%.

Full-aperture tests of high-damage-threshold silica components were also conducted for the first time this quarter. The goal of the campaign was to test a NIF-like FOC and debris shield at average 3ω fluences of 6 J/cm^2 in 3-ns square pulses for 20 shots. The initial shot sequence consisted of a five-shot ramp and eight shots at 6 J/cm^2, with only the FOC containing frequency conversion crystals and a final focus lens installed in the test mule. Optics condition during this part of the campaign was quite good. After installation of a debris shield and seven additional shots at 6 J/cm^2, extensive damage occurred on the output surface of the tripler and the input surface of the lens. Evidence suggests that the damage was related to a back reflection from the debris shield, which was misdirected onto the Al wall of the FOC.

The first of the French CEA campaigns was completed this quarter. The purpose of the campaign was to test fused silica windows with a large-aperture, high-quality 3ω beam to determine thresholds for filamentation and damage that could be extrapolated to the target chamber vacuum windows on the LMJ. Two parts were tested (Suprasil 312 and Herasil 1SV) in the test mule vacuum chamber at a plane 2 m downstream of the *f*/20 3ω focus, which was spatial filtered. Onset of filamentation occurred at an aperture-averaged intensity-length product of between 25 and 30 GW/cm as measured at a pulse duration of 200 ps. High-fluence testing up to aperture-averaged fluences of 13 J/cm^2 in 3-ns produced damage that was significantly less than expected from off-line tests.

National Ignition Facility

Overall progress on the NIF Project remains satisfactory for the third quarter of FY98. NIF Conventional Facilities construction made good progress, and a total of eight DOE/OAK Performance Measurement Milestones were completed. In June, Walsh Pacific (CSP-3) finished its major concrete work in the Target Building and Switchyards essentially on schedule. Nielsen Dillingham's (CSP-4) steelwork in the Laser Bays started in April, about six weeks later than originally planned. This delay was anticipated during the bid period for CSP-9, Laser Building Finish & Central Plant, so the milestones were adjusted by four to six weeks to compensate. The critical path for Conventional Facilities, which runs through CSP-9, is delayed by roughly two to four weeks, but the fourth quarter 03 Project completion date is being held.

In Special Equipment, 89% of the Mid-Title II (65%) design reviews, and 24% of the Title II (100%) final design reviews have been completed. Design reviews continue to be successfully held, and

drawing production continues, although at a rate slower than planned. Some reviews and the follow-on procurement activities are now beginning to lag the schedule dates, which reduces the available schedule float for these activities. Efforts are now under way to streamline the review process to maintain the FY98 Title II completion schedule. The Beam Transport Vessels and Enclosures procurement was awarded early in June, and the Target Chamber contract is on schedule.

In Optics, facilitization is moving well at all NIF vendors as they prepare for pilot production in late FY98 or in FY99. Zygo and Corning will both begin pilot production in the fourth quarter in portions of their facilities while they complete facilitization tasks in other areas. Schott, Hoya, and Tinsley will begin their pilots in the first quarter of 1999. KDP rapid growth and finishing pilots have already started at LLNL, and the external-vendor rapid-growth pilots are set to begin in early FY99 at Cleveland Crystal and Inrad. Facilitization at the University of Rochester Laboratory for Laser Energetics and Spectra-Physics is on schedule to begin their pilots later in FY99. The longest lead substrate material, polarizer substrates, has already been received for pilot. The first NIF production optics orders were awarded to Schott and Ohara for the polarizer substrates, and to Ohara and Pilkington for LM3 mirror BK7 substrates.

Key Assurance activities during the third quarter to support the Project included Assurances safety support and QA surveillance of major concrete pours including the initiation of shielding concrete pours. Litigation activities included litigation support to the DOE for the settlement of 60(b)—Agreement to prepare a Programmatic Environmental Impact Study supplement analysis and to conduct specific evaluations and surveillance of potential buried hazardous materials—and the overall litigation against the Stockpile Stewardship Program's *Programmatic Environmental Impact Statement*; the NIF Construction Safety Program; interface with the Institutional surveillance for buried hazardous/toxic and/or radioactive materials; Risk Management Plans; the *Final Safety Analysis Report*; assurance surveillances and audits; and support of environmental permits. All are on schedule.

There were no Level 0, 1, 2, 3 milestones due during the third quarter. There were 26 DOE/OAK Performance Measurement Milestones due, and 21 were accomplished. There was a total of 56 milestones due through the end of the third quarter, and 52 have been accomplished, for an overall variance of 4. This is based upon DOE/OAK's concurrence with Rev. c of the FY98 Milestones, which was effective May 1, 1998.

The current assessment of Project status remains similar to that stated at the end of the second quarter; that there will be no change to the fourth quarter 01 Level 2 milestone for the End of Conventional Construction, nor to the fourth quarter 03 Project Completion date. However, it is still anticipated that there could be a three- to six-week impact to the fourth quarter 01 Level 4 milestone for the start-up of the first bundle. Due to the status of Laser Bay steel erection, the current assessment is that there may be a four- to six-week impact to other internal milestones for construction. The Project Office is working with Nielsen Dillingham to determine how best to accelerate the steel work early in the fourth quarter. The Integrated Project Schedule is also being reviewed to find potential work-arounds to minimize impact to the first bundle.

Site & Conventional Facilities

NIF Conventional Facilities construction made good progress during the third quarter and completed a total of eight DOE/OAK Performance Measurement Milestones. Of these, five of six due in the third quarter plus two remaining from the second quarter were completed, and one due in the fourth quarter was completed early. In June, Walsh Pacific (CSP-3) finished their major concrete work in the Target Building and Switchyards essentially on schedule (plus nine rain days), as a result of several months of accelerated double shift work (see Figure 1). Nielsen Dillingham's (CSP-4) steelwork in the Laser Bays started about six weeks late in April, was delayed by rain in early May, then began to accelerate in late May and early June. However, efforts to further accelerate the schedule in June did not materialize. Therefore, due to the lack of progress on CSP-4 steelwork in the Laser Building, there is approximately a four to six

FIGURE 1. Switchyard 1 concrete pour. (40-60-0598-1213#7pb01)

week lag in the completion of internal milestones for this subcontract. This delay was anticipated during the bid period for CSP-9, so the milestones were adjusted by four to six weeks in CSP-9 to compensate for the delays coming from CSP-4. However, the critical path for Conventional Facilities that runs through CSP-9 is delayed by roughly two to four weeks. In addition, the field team is closely watching progress to ensure that the facility will be essentially dried-in by the start of the rainy season. Efforts to accelerate roofing activities under CSP-4 may be undertaken to ensure the dry-in of the facility.

June was generally a positive month for the NIF Conventional Facilities construction effort; clear weather allowed work to proceed at full speed. Walsh Pacific (CSP-3) completed its work and demobilized from the site. Nielsen Dillingham (CSP-6/10) began work in the Target Area, Switchyards and Diagnostics Building, and has made excellent progress to date. Although access to the work area was delayed for Nielsen Dillingham for CSP-6/10 due to Walsh's late departure, the team anticipates full recovery of the schedule. Work in the Optics Assembly Building (OAB) made good progress in the third quarter. The erection of structural steel began several weeks early, placing the work on the OAB slightly ahead of schedule. The site utility work is progressing at a fairly slow pace; multiple prime contractors on the site are creating some challenges to the team's ability to open excavations that do not choke the site circulation. The work has not progressed per the initial schedule, however, there has not yet been an impact to the critical path of the Conventional Facilities work. Significant, visible progress has resulted from field efforts in June.

Three FY98 DOE/OAK Performance Measurement Milestones were achieved on the NIF site in April: the issuance of the Notice to Proceed for CSP-6/10, the start of Laser Bay Core Structural Steel Erection (see Figure 2), and the completion of Laser Bay Footings. One DOE/OAK milestone, the completion of Storm & Sanitary Sewer Lines, was delayed until October. This adjustment does not affect the critical path on either Conventional Facilities or the Project. One milestone, Switchyard Mat Slabs Pour, was achieved in May. Four milestones were achieved in June: Start Concrete F/R/P/C East Wall for Switchyard 2, achieved with the erection of forms; Start Overhead Platform Set-up for Laser Bay 2, achieved with delivery and staging of the platform materials; Start Concrete F/R/P/C for Target Bay Cylinder, achieved with erection of forms; and OAB Start Structural Steel Erection, originally scheduled for July, also achieved in June. The milestone not achieved was the Complete Structural Steel Erection for the Laser Bays, currently estimated for completion in August, seven weeks later than originally planned.

- All contract work by Walsh Pacific, CSP-3, was completed in June except for the curbs that sit on top of the footings between grids 28 and 30 (between the Laser Building and the OAB). This work was removed from CSP-3 and added to CSP-5 to allow for better access between the Laser Building and the OAB. The total concrete placed was 6872 yards during the third quarter. This contract is considered to be 100% complete.
- Steel erection of the Laser Building Core by Nielsen Dillingham, CSP-4, was completed in June, and bolting and plumbing is approximately 25% complete. Erection of Laser Bay 2 is approximately 75% complete, but bolting and plumbing has not started.
- Four isolation pads, slab on grade, and return walls bordering the OAB equipment pads were placed in three separate pours by Nielsen Dillingham, CSP-5. The Special Equipment granite slab was placed on the spatial filter tower alignment pad.
- Work began in earnest for Nielsen Dillingham, CSP-6/10, during June. The formwork for the Target Bay 18-in. and 30-in. columns was put in place with rebar. The first concrete pour for the columns was completed utilizing a 52-m pump truck and the 5000-psi shielded concrete. The second pour for the remaining columns in the Target Bay was also completed. All of the first three pours were completed to the –22.75-ft level.
- The majority of work performed in June by Hensel Phelps, CSP-9, was related to the site utilities. Material for the overhead platform to be used in the Laser Bays was received, and staging began in June. Site utility work is continuing, including installation of mechanical utility bundles at the East side of the site up to the Central Plant and installation of chilled water piping, hydronic piping, domestic water, and sewer lines around the OAB.

FIGURE 2. Looking north from Switchyard 1. (40-60-0598-1007#3pb02)

Special Equipment

Design reviews continue to be successfully held, and drawing production continues, although at a rate slower than expected. Procurement packages are being reviewed, revised, and released. Detail planning for FY99 is well under way, and reviews of the FY99 Cost Account Plans have been started.

Mid Title II (65%) design reviews were held for the Final Optics Damage Inspection System, the Pulse Synchronization System, the Laser Injection, and for the Operations Special Equipment Control System Supervisory Controls. Final (100%) design reviews were held for the Target Chamber Vessel, the Line Replaceable Unit (LRU) Assembly Verification System, the Vacuum System, the Supervisory Control (Applications), Target Area Auxiliary Systems, and the Communications/Environment Monitor System. In addition, Final Documentation and Procurement Reviews were held for the Beam Transport Enclosures for the structural supports for the Transport Spatial Filter (TSF), Cavity Spatial Filter (CSF), and Preamplifier Module Support Structure (PASS). Design review reports were prepared and released for the Supervisory Control (Framework) 100%, the Final Optics 65%, the Computer Systems 100%, and the Target Area 65% reviews. Changes to the required content for the 100% design reviews are being considered to reduce the amount of preparation and presentation time. This is based on the successful completion of most of the 65% reviews focusing on the design, and intent to focus the 100% reviews on the procurement readiness and design basis book completion for that subsystem.

Laser Systems. The Laser Systems detailed designs are progressing roughly according to plan. Drawings are being completed at a rapid pace, and manufacturing prototypes or first-article prototypes of various assemblies are being procured and tested. The emphasis of prototype testing has shifted from optical performance to more engineering-like concerns such as cleanliness, vibration, installation, assembly, and kinematic mounting.

- During the third quarter, the Preamplifier Module (PAM) prototype was assembled, and testing began. The electronics bay was installed and tested, and the regenerative amplifier was activated. Alignment of the multipass amplifier is in progress in preparation for energy extraction tests. This prototype will be used during the next quarter to validate the PAM design relative to the system requirements. Numerous technical issues with the design of the Master Oscillator Room (MOR) hardware were also addressed. Stability issues with the baseline oscillator design motivated the identification of several commercially available alternative oscillators. The most promising of these have been ordered to validate their performance relative to their specifications. The FM-to-AM conversion noted during the last quarter motivated a change in the fiber used in the MOR design from a polarization-maintaining fiber to a polarizing (PZ) fiber. The PZ fiber has been specified and a test-run ordered from 3M for testing. The prototype arbitrary waveform generator system was coupled with the electro-optic modulator to produce the baseline Haan optical pulse from the MOR system (see Figure 3). Alignment testing of the prototype PAM was completed during the past quarter. The procedure was defined, and the rails were successfully aligned. Maxwell Physics International presented a successful design review for the PAM power-conditioning unit.
- During the past quarter, four tiger teams were established to analyze and interpret amplifier performance data collected using the AMPLAB prototype. Computer codes for reducing AMPLAB gain and wavefront data were revised and tested. Much of the wavefront data were reduced and compared with model predictions. Reduction of the gain data is under way. Additional thermal recovery experiments were performed on the AMPLAB after insulation was applied to the outside surfaces of the amplifier, beam tubes, and mirror towers, to improve thermal stability; this data is being analyzed. Detailed hardware designs are proceeding at a rapid pace, and a prototype amplifier Frame Assembly Unit was ordered and is being fabricated. The slab holder design was modified to address slab abrasion and assembly difficulties experienced on the prototype. A management review was conducted for the conversion of Building 381W into the Frame Assembly Unit Assembly Area. The plan was approved, and the Program will cover the costs for the conversion, including the clean room.

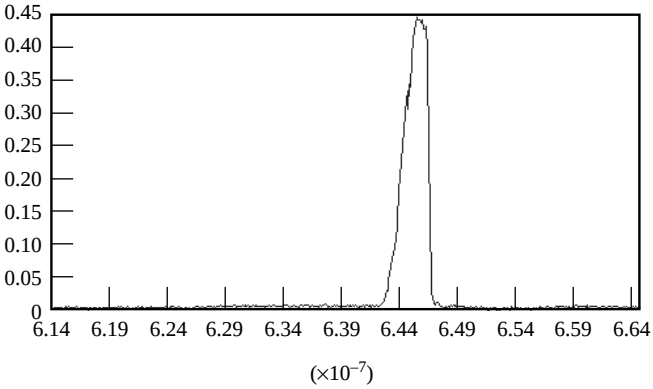

FIGURE 3. Optical pulse with a contrast ratio of 175:1. (40-60-1198-2258pb01)

- The Plasma Electrode Pockels Cell (PEPC) prototypes underwent numerous mechanical and optical tests during the third quarter to validate the design. The kinematic mount design was tested to demonstrate adequate repeatability, capture range, and reliable operation of the mechanisms. The design performed very well overall, and minor modifications were noted for the production hardware. Vibration testing was completed to provide data for system stability performance models. A detailed tolerance analysis was completed for the PEPC, accounting for insertion/removal, alignment, structure and manufacturing tolerances. Optical performance of the cell under nominal conditions demonstrated that the design exceeds requirements for both "on" and "off" states. The design of the PEPC assembly fixture was completed, and the drawings are being reviewed. The PEPC front-end processor (FEP) prototype was deployed in the PEPC Lab to test compatibility of the controls with the harsh EMI environment of the PEPC.
- The Power Conditioning System Mid-Title II (65%) design review was held in April, and the design was commended by the review committee. A full prototype of the Power Conditioning System module was completed with the procurement of parts for the first-article module. Actual procurement of the first-article components will provide for firm cost estimates for production. Nearly all components arrived during the past quarter, and assembly and installation has begun. A variety of critical fault modes were simulated using the prototype module, including capacitor and bus faults. The system performed as expected and minimal damage to the hardware was sustained. Most notably, the 1.4-mega-ampere bus fault validated the performance of the module enclosure, blast doors, and fire prevention strategy. The ST-300 switch testing was completed in May. Testing of the ST-300E at greater than 540 kA indicates that switch lifetime will be in excess of 1500 shots.

Beam Transport System. In this quarter, all major structural and vessel packages for upcoming procurements were finalized and reviewed. The majority of laser bay steel structures were issued for bid. Contracts for the laser bay steel-mill order and the fabrication of spatial filter vacuum vessels were awarded. Shipment of 1000 tons of stainless vessel plate was initiated. Over 500 drawings were completed and released under Configuration Management. Much progress was made in streamlining the submittal process to facilitate the timely release of procurement packages. Construction Planning activities developed into focus groups for the PASS, the War Zone (i.e., the optical system in the TSF optical plane area), Periscope (the structure that supports the PEPC, polarizer, laser mirrors LM2 and LM3), and Switchyards to establish more detailed links in the Integrated Project Schedule.

- Production of the spatial filter stainless plate is near completion with final product completion slipped to July and final invoicing anticipated by the end of August. Shipment of plate material to vessel fabricators is in progress and approximately 60% complete. Title II procurement review was completed for the spatial filter vacuum vessels, including approval of end vessel and center vessel engineering safety notes. Contracts were released in June for vacuum vessel fabrication.
- The detailed drawings for the Switchyard Beam Tubes are 95% complete. The horizontal quads remain to be detailed and should be completed by early July.
- The Roving Mirror Diagnostic Enclosure design is proceeding. Substantial progress was made incorporating updated interfacing structures and assemblies into the Pro-E model. The updated assembly details allow for development of part details based on real fit and dimensional constraints.
- Design development was concentrated on the large interstage components consisting of docking frames at the spatial filter end vessels and at the Switchyard wall to ensure fabrication and delivery do not impact critical path closure of facility openings. Planning and preliminary development of options and methods for cleaning beam tube enclosures is progressing.
- During this quarter the Spatial Filter Vacuum System Title II 100% Design Review was completed.
- The Switchyard #2 structure drawing package was completed and submitted into Configuration Management. The Title II Procurement Review for SY#2 was scheduled for early July, and the draft Statement of Work and fabrication specification were distributed for comment.
- The Power Amplifier, Main Amplifier, Laser Mirror 1, and Periscope support structure design drawings were completed. The Laser Bay Support Structures Fabrication Specific-ation is completed. The CSF Optical Bench, TSF Optical Bench, Injection Structure, and PASS design calculations were completed. Thermally sprayed aluminum was chosen to coat the interior of the Laser Mirror 1 and the Periscope after examining many paints, ceramic, and thermal metallic

applications. The aluminum coating will be mechanically finished to a 125-rms finish to accommodate cleaning.

- A review of thermal analysis in the Laser Bays was presented. A significant conclusion was that the fluorescent lights under the Laser Bay beam cavities will adversely affect the wavefront of the laser. The solution was to provide motion detectors to power these lights only when needed, minimizing the thermal effects. In addition, a laser alignment control system override may be needed to shut lights off on demand to allow the structures to thermally stabilize.
- The 100% Title II review for the LRU Assembly Verification System was presented in May. The comments received were helpful and did not reveal any major issues.
- Good progress was made in developing and demonstrating an acceptable transport mirror attachment design. At an internal review in April, it was recommended to proceed with two concepts—an expansion arbor and an undercut. These have been tested at subscale. The results for both were very encouraging, with mirror surface deformations less than 20 nm.
- Testing of actuators is producing useful information for final design. The reliability, availability, and maintainability (RAM) testing of the harmonic drive actuators is well under way (>2 million cycles) and is showing that design to be robust. Testing of the friction drive actuator, planned for use on the periscope LRU, has revealed that there is some slippage between bearings and races that is load dependent. This error is being quantified to determine whether the controller can accommodate it or whether a design change will be necessary (i.e., use the harmonic drive actuator).
- Testing of prototype hardware continued. The shutter/beamdump (shown in Figure 4, below left) tests indicated that a design modification is needed to prevent the gate valve from binding during operation. Linear bearings will be used. RAM testing of this LRU will begin in July. The LM4 (switchyard mirror, below right) LRU is undergoing modal testing to confirm the finite element analysis of the individual mirror mounts, the frame assembly, and the kinematic mounts.

FIGURE 4. The shutter/beamdump testing, shown at left, and the LM4 switchyard mirror, shown on the right. (40-60-1198-2259pb01) (40-60-1198-2404pb01)

Integrated Computer Control System. Title II design progress is satisfactory. Five out of eight scheduled 100% reviews have been completed. Three reviews were completed in the third quarter: the Video Distribution System, a prototype of which was demonstrated at the review; the Supervisory Software, followed by two weeks of advanced training in object-oriented software engineering (construction of the first phase of the Production Prototype for demonstration in October 1998 has started); and the Communications System and Facility Environmental Monitor, also projected to meet deployment cost goals.

- Title II work is complete for computer systems. Installations of the NIF Testbed server computer, network diagnostic equipment, and numerous software items were completed in June, including graphical user interface tools, network management software, and security upgrades. Significant upgrades to the capability of the Rational Ada-95 compiler and ORBexpress object request broker for Solaris supervisory and FEP systems were successfully delivered as a result of outstanding collaboration between the vendors.
- The design for the first Production Prototype of the NIF Computer Control System software was featured at the 100% review. The prototype will be implemented during the fourth quarter to be demonstrated and submitted for testing in October 1998.
- Prototype testing of the t-1 Abort System on the programmable logic controller platform was performed. The system was simulated for one laser bay, and the terminal-to-terminal response time of the system was measured to be 1.8 ms. Although an additional 5 to 15 ms is expected when all overhead is accounted for, these results are well within the 70-ms real-time processing requirement of the system. The Industrial Controls Requirements and Design Description document was revised to reflect the final design, and the detailed failure modes and effects analysis was completed for the t-1 Abort System.
- Optics damage inspection data was generated from Beamlet experiments, locating an optic containing a broad spectrum of flaws at several positions in the beamline that was imaged repeatedly with various pinhole configurations, camera integration times, and other system configuration variations.
- A deployment model of the Control System software framework was created that allocates computer processes and key framework objects among the generic FEP, supervisory workstation, file server computers, and control points. A specific deployment model of the first production prototype was then created that depicts the vertical slices (i.e., the subsystem architecture from FEP level to supervisory level) to be built for all supervisory applications and participating FEPs.

Optomechanical Systems Management. Title II design activity is moving towards completion in several areas. The LRU Assembly Verification System completed its 100% design review, and the drawing package was released under Configuration Management (CM). Optical design prepared for its upcoming 100% review. Internal reviews of subsystems in final optics resolved lingering, detailed design questions. The final optics assembly (FOA) prototype hardware (full-scale) was assembled, and integrated testing began. The shutter beamdump hardware was received for validation testing, and the transport mirror assembly was assembled and underwent modal testing.

Optical Design

- The final optics damage inspection system design was modified to use only fused silica components. This reduces the susceptibility of the system to damage due to background radiation (neutron-activated) in the target chamber. The design was further improved to reduce the sensitivity to element decenter and tilts. The optical design of the final optics damage-inspection system was presented at the 65% review for that system with no optical design issues identified.
- The final optical design detail for the transport mirrors was described in a memo. Target area mirrors LM6 to LM8 should be offset slightly to maximize use of the mirrors' clear aperture. This information was communicated to mechanical design groups in optical mounts and target area structures for inclusion in their detailed Pro-E models.
- Ghost workshop #3 was held in May to discuss the extensive analysis that has been performed on stray light in the FOA. Numerous threatening ghosts near the mechanical structures have been identified, their fluences estimated, and areas for absorbing materials or baffles identified.
- Optical fabrication drawings for the transport mirrors were released (blank, finished, and coated). The fused silica blank drawings were revised based on a request from Optics Manufacturing. Thus, 60 drawings needed for large optics manufacturing are under CM. The release of the six KDP crystal drawings needed for Title II is being paced by resolution of detailed specifications and associated metrology for the doubler and tripler.

Optical Components. The first NIF production optics order has been placed with the awarding of polarizer and LM3 mirror BK7 substrates. Due to long lead times, polarizer substrates for pilot production were ordered more than a year ago from Schott and Ohara. Mirror BK7 substrates were awarded to Ohara and Pilkington for pilot production with fixed price annual options for all of production.

- Mirror substrate blank drawings have been revised and released based on final dimensions and specifications. Firm fixed price contracts were awarded in June for mirror substrates for the NIF mirror pilot, with firm fixed price annual options for production of all the glass required for the NIF. Competitive bids were received from four glass companies, and awards were made to two vendors: Ohara and Pilkington. Each received a contract in June for one-half of the pilot quantity of mirror substrates.
- The polarizer substrate blank drawing was revised and released based on final dimensions and specifications. Firm fixed price contracts were awarded to Schott and Ohara in June for polarizer substrates for the first half of NIF production, with firm fixed price options for the remaining half of production to be awarded in FY01.
- Extensive testing of a variety of materials by laser exposure, flashlamp exposure, and cleaning has shown that burnished, thermally sprayed aluminum meets all performance requirements for the interior of the laser by a wide performance margin.

Laser Control. The last of the 65% design reviews were completed in May, and Laboratory activity supporting prototype testing continued to increase.

- The 65% design reviews for Alignment Systems, Final Optics Damage Inspection, and Pulse Synchronization were presented during the third quarter for a total number of 22 Beam Control reviews during Title II. All remaining reviews will be at the 100% level.
- Initial measurements of optics transmission degradation in vacuum and in static nitrogen or argon environments suggest that parts in static gas are less vulnerable to outgassing than those in vacuum, and that the specification for outgassing in vacuum enclosures may have to be tightened.
- Most of the input sensor optical component drawings have been released and are being sent out for prototype fabrication. Mechanical fabrication will take less time, and most mechanical drawings are in checking. Some prototype mechanical parts are already on order, including the two-position shutter and optics insertion device that will also be used in other locations.
- The first prototype light source unit was assembled for the LM3 centering location. It will provide two pairs of 1.05-μm beams for comparison with similar reference sources at LM1 and the FOA.
- The optical configuration drawing for the Output Sensor was completed. Assembly of the prototype Output Sensor was begun early in the quarter and is now complete. The test stand for the sensor package was also completed, and the package and test stand are now undergoing integrated testing.
- The lab setup for integrated testing of all power measurement components including Output Sensor fiber launch optics, fiber bundles, fiber bundle-to-photodiode coupler optics, photodiode, signal dividing transformer, and transient digitizer was assembled in the Optical Sciences Laboratory.
- A prototype local-energy node board including the latest dynamic range enhancements was prepared for use with the Preamplifier Module prototype. Its performance will be verified by calibrated test equipment available in Nova.
- The Raytheon deformable mirror prototype was delivered and is ready for testing in the NIF Wavefront Systems Laboratory. The ThermoTrex deformable mirror prototype has not been delivered, but the acceptance tests at ThermoTrex were completed. Finite-element models of both vendor mirrors were generated at Livermore to calculate influence functions for inclusion in the wavefront correction modules of the NIF propagation codes.
- The completeness of the NIF beamline aberration model was improved by the addition of mounting and gravity sag aberration estimates. The LLNL-developed finite-element model influence functions for the Raytheon mirror were put in proper form for use in the adaptive optics part of the propagation code, and actual calculations incorporating these changes have recently begun.

Target Experimental Systems

- The Target Chamber Final Design Review was successfully completed in May. Comments from that review have been collected and initial replies issued. The majority of the 18-sphere plate sections have had the weld joint configuration machined at Precision Component Company. The first three plates were shipped to Pitt-Des Moines in Pittsburgh for a trial fit to evaluate the effectiveness of the shipping cradles, fitting gear, handling procedures, and

overall matching of the three plates that will form the bottom of the target chamber.
- Construction work on the target chamber temporary enclosure, built on the E7 parking lot, continues with the completion of the 60-ft-diam, 62-ft-high enclosure. The enclosure is similar to an oil storage tank. It is made from 0.25" steel plates, seven courses high. A polar crane, HVAC, insulation, lights, and a removable roof will be added.
- The prototype beamdump was placed on Nova, and samples changed out weekly for three weeks of mostly gas-bag shots. An additional fused silica optic was added to the samples for off-line laser damage studies. The beamdump survived without excessive stainless steel ablation. Then, the prototype beamdump was placed back on Nova for a week of hohlraum shots. After a week of high-yield shots, the beamdump will be removed from the chamber and additional analysis performed.
- The investigation of the trade-offs between increased protective disc sizes for the target positioner and the need to clad some portion of the cryostat itself has been carried forward. Although a larger protective disc, which can completely shield the cryostat, gives rise to more ablation than the combined ablation from a smaller disc and the cryostat, the difference may not be enough to warrant periodic recoating of the cryostat; as the total ablation of relatively benign B_4C is still less than the amount of debris from the target assembly and the first wall. It now appears that a sufficient quantity of cryogens for several days' holding can be accommodated in a cryostat of a geometry that can be completely shielded from target x rays.
- A web page has been developed to share diagnostic design information with representatives from LLNL, LANL, SNL, LLE, and AWE. The web page is still under review for content and organization and will soon be password accessible by diagnostic users.
- A design review for the NIF Grounding and Shielding Plan review was conducted in April, and no significant problems were identified in the review. The new draft of the NIF Electrical Grounding, Shielding & Isolation Plan has been entered into Project Database Management for review. A detailed analysis of electrical noise induced in cables in the Target Bay was conducted, and the design for the Target Chamber Ground Monitor System is being developed using commercial ground fault monitor/alarms systems.
- As a result of revised calculations performed by CSA for the seismic loads applied to the top of the pedestal and the target chamber to floor restraints, there has been some concern that the loads may exceed cited loads that were given to Parsons in an interface control document (ICD) in August 1997. Considerable design and analysis effort has been expended to resolve the differences between the existing calculations.
- A revised tritium usage projection for NIF has modified plans for implementation of the tritium-related systems. The schedule for implementation of all environmental protection elements has been extended.
- The 100% Design Review for Target Area Utilities & Cable Trays was held in June. No significant design action items were identified. All Title II deliverables have been completed and submitted to the Project Office.

Final Optics Assembly

- Significant progress was made in understanding and projecting the frequency conversion performance for the NIF final optics design. At a scientific review held in April, the converter design, its requirements, and error budget were presented. Requirements from this budget have since been flowed down to metrology equipment, crystal fabrication, coating performance, and mount tolerances.
- As a result of the intensive Beamlet experiments and the change-out/testing of different optical components, the single prototype final-optics cell has been assembled and disassembled many times. This heavy use has proven the robustness of the mechanical design and led to development of very detailed procedures for clean assembly.
- Major pieces of prototype hardware were assembled in the high bay of Building 432: the vacuum isolation valve, the calorimeter chamber, debris shield modules, four optics modules (one manufactured as a welded assembly and three by a casting process), and the large test stand. The integrated testing of the full-scale assembly began. The orientation of the FOA shown in Figure 5 simulates installation on the bottom half of the target chamber. Planned tests include mechanical fit-up and handling, vacuum pumping rates, cleanliness evaluations, and in-situ operation of debris shield cassette.
- The first round of debris shield cassette testing for cleanliness was completed. Preliminary results indicate that some minor design modifications are needed to eliminate sag and "walk"problems as the slide exits the Nylatron edge guides.

- The design progress toward final, detailed FOA design drawing packages was good for several subsystems. The final optics cell is in excellent shape, the vacuum isolation valve is nearly complete, and the alignment fiducial arm design drawings are in checking.
- Good progress was made on CAVE (crystal alignment and verification equipment). The "first light" milestone was met in April. Semi-automated measurements of frequency conversion of a doubling crystal (2ω rocking curve) were completed in May. The control software for fully automated, full-aperture scanning measurements is proceeding well and will be operational next quarter. Detailed, engineering subsystem verifications (e.g., stability of mounts, performance of autocollimators) are under way.

Operations Special Equipment

Title II design progress is proceeding well. Hardware prototyping continues to increase in volume and in data collected. Several internal key milestones were accomplished this quarter.

- An integrated 3D model of the Laser and Target Area Building (LTAB), OAB, and corridor is in progress for a Material Flow design review. The process to bring manageable-size files together and maintain a high level of detail has been developed by using a series of benchmark tests, resulting in a process that allows the designers to use Intergraph files with 3D Studio, gain a huge time savings, and maintain a high level of detail for modeling.
- The detailed design in the bottom loading (BL), top loading (TL), side loading (SL), switchyard, and target area delivery systems is progressing well. The docking structure for the BL system has been initiated and will be used for the canister docking as well as for the insertion testing of the PEPC, Spatial Filter, and Periscope LRUs.
- The Final Design Review for the Laser Bay Transport System with RedZone Robotics/AGV Products was completed this quarter.
- The assembly and testing of the prototype hardware is progressing well. All components are in for the flashlamp cover removal mechanism and assembly was started in May. Load testing of the permanent carriage for the BL universal system was completed in May, and some redesign is expected due to the results. A vacuum cover removal operation was completed with the TL scissors/latching mechanism as well, and the system performed flawlessly.
- The OAB hardware designs and the simulations continue to progress well. All ICDs with optical mounts, amplifier, and alignment systems groups are revised and signed. A top-level assembly model for the OAB was completed this quarter, and the docking station and assembly stand concepts are complete for the amplifier and the generic docking ports.
- The Supervisory Controls team has made excellent progress, completing the Mid-Title II (65%) Review in June, with strong project endorsement and interactions. The software requirements specification and rational rose model for the supervisory server was completed. A prototype implementation of the supervisory server framework and event services, integrated with the FEP control software, is in progress.

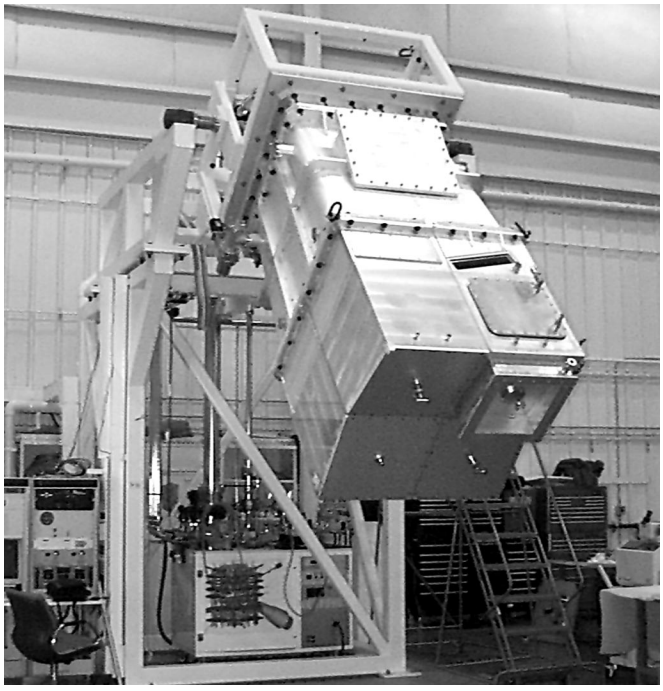

FIGURE 5. Prototype FOA hardware being assembled in the high bay of Building 432. (40-60-1198-2260pb01)

Start-Up Activities

- The month-end June status of the Integrated Project Schedule showed no impact to Level 0–3 milestones. Work continues with the Conventional Facilities group to establish a baseline for CSP-9 and CSP-6/10. Once baselines are established, Project Milestone dates and definitions will be adjusted.
- As part of the FY99 CAP planning process, Start-Up has completed definition of the FY99 workplan to develop the present First Bundle

Operational Test Plan into a complete set of Operational Test Procedures. Additionally, the Start-Up Preliminary Staffing Plan for the First Bundle was completed in detail. A detailed list of activities for the Start-Up group was laid out for FY00 and FY01. The composition of the Start-Up Laser Operations teams was defined, in addition to the scientific support staff, who will provide expert assistance and handle data processing and evaluation of the operational test data.

- Optics Processing is the first of 12 to 15 functional areas to work with Start-Up in preparing operations training materials following a performance-based training method. A schedule driven by Project milestone dates and Title II 100% design review dates has been developed to determine the order in which Start-Up will work with various groups to prepare training materials and operations procedures.
- Start-Up staff has been working on the conceptual design of a metrology station to measure wavefront errors in mounted optics. This continued through May and June with the goal of a conceptual review held the first week in June. A solid concept was developed to test LM4, LM5, LM6, LM7, LM8, amplifiers, and PEPC.
- A plan has been developed laying out all NIF operational readiness requirements through the end of the project and beyond. This plan is presently being reviewed internally and will be discussed with DOE within a few months.

Optics Technology

Facilitization is moving well at all NIF vendors as they prepare for pilot production in late FY98 or in FY99. Zygo and Corning will both begin their pilots in the fourth quarter in portions of their facilities while they complete facilitization tasks in other areas. Schott, Hoya, and Tinsley will begin their pilots in the first quarter of 1999. KDP rapid growth and finishing pilots have already started at LLNL, and the external-vendor rapid-growth pilots are set to begin in early FY99 at Cleveland Crystal and Inrad. Facilitization at LLE and Spectra-Physics is in good shape to begin their pilots later in FY99. The longest lead substrate material, polarizer substrates, has already been received for pilot production, and orders are in place for mirror and polarizer substrate production.

- The last two crystal growth stations at LLNL became fully operational, went through their first validation tests, and are now being used for growth runs. Coating development at LLNL was completed and the first convex aluminum platform was coated with the improved process. Six tanks are now running as part of the LLNL pilot.
- Fabrication of the Finishing Diamond Flycutting Machine by the Moore Tool Company in Bridgeport, Connecticut, is progressing well. Moore Tool plans to ship the machine by the end of July 1998, after debugging the major mechanical and control systems. The flycutter design and most major assembly are complete. LLNL site preparations for accepting the Moore machine are also complete.
- LLNL has agreed to Corning's proposed plan to accelerate pilot and production of fused silica in FY99 to take advantage of the current world slump in the fused silica market, driven by a drop in the semiconductor industry. Corning will be ready to ship pilot glass in October, matching the original schedule and eliminating a previously expected slip of three months. Corning demonstrated a new inspection technique that will allow them to detect solid inclusions much smaller than their current 80-μm limit. If required, this technique may be used as a factory quality control tool to ensure 3ω glass meets the proposed new 3ω inclusion specification.
- Tinsley is making excellent progress on their NIF Lenses and Windows Finishing Facility building. Although the new NIF building will not be completed until November, pilot production of NIF optics will begin in October (completing a DOE/OAK Performance Measurement Milestone). High-volume demonstration runs will be carried out in the current facility using NIF equipment and NIF processes to fabricate lenses for the NIF. Production of pilot optics will switch to the new building when available midpilot.
- Initial acceptance testing of the cleaning line equipment for Zygo's facility was done at the equipment manufacturer, Forward Technology. Installation at Zygo is approximately 80% complete. Zygo has been evaluating cleaning detergents on small material samples with their existing equipment.
- Facilitization at Spectra-Physics is proceeding on schedule. The interferometer isolation pad was poured and is curing. Interestingly, NIF construction has delayed availability of concrete at Spectra-Physics. Walls for the metrology labs are in construction as are air-handling systems. Facilitization at LLE is proceeding on schedule. Construction has begun on conditioning labs, and the contract was awarded for the 1ω interferometer at LLE. The counter rotating planetary hardware at LLE has also been assembled and cleaned.
- A WYKO white light microinterferometer was installed and performance verified during June. The unit is being used to verify the etch depth of samples from etch monitor development. Modifications are being made to enable this

instrument to also provide roughness and power spectral density waviness II measurements for mirrors, lenses, windows, crystals, and amplifier slabs.

Upcoming Major Activities

During the fourth quarter of FY98, Conventional Facilities will complete the CSP-4 erection of the Laser Building steel and much of the roofing and siding. In the Target Building, the concrete walls for the switchyards and the Target Bay cylinder will begin to rise. The OAB steel work will be completed, and the building will be dried-in. In Special Equipment, the majority of the 65% and 100% design reviews will be completed, and procurements will continue to be initiated for Beam Transport items such as the Laser Bay Structures. In Optics, preprocurement reviews will be held for the major components, and the vendor facilitization activities will continue.

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